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PROTECTION OF MOORING BUOYS

PART VI. RESULTS OF FIFTH RATING INSPECTION

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PROTECTION OF MOORING BUOYS — PART VI. RESULTS OF FIFTH RATING INSPECTION

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by

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ABSTRACT

This is the sixth of a series of reports on the protection of mooring buoys. Fourteen test buoys were given their fifth rating for extent of coating deterioration, corrosion of steel, and fouling. A fifteenth buoy had been removed from testing at the time of the fourth inspection because of advanced deterioration. The coating systems on four of the buoys were in good condition, and those on the ten others showed varying degrees of moderate deterioration. Two sets of thirteen test panels each, coated with the different coating systems used on the buoys, were given their fourth rating inspection after 2 years of service. One set was exposed in San Diego Bay and the other in Port Hueneme Harbor. The condition of the coating systems on the Port Hueneme panels showed a general correlation with the test panels and buoys in San Diego. On those buoys with antifouling paints, no detectable antifouling protection remained after 25 months, but on the test panels at both locations two antifouling paints were still retarding fouling after 2 years.

Three of the test buoys were cathodically protected with zinc anodes. The level of protection was great enough to mitigate rusting on the underwater portions of these buoys.

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INTRODUCTION

Because the presently specified coatings for mooring buoys have performed unsatisfactorily, the Bureau of Yards and Docks assigned the Naval Civil Engineering Laboratory to find or develop better corrosion protection for fleet mooring buoys. The assignment included investigation of both protective coatings and cathodic protection.

A field-test program was initiated in San Diego with fifteen peg-top riser-chain mooring buoys (Mark I or Mark II). Thirteen different coating systems were used, and a cathodic protection system was installed on one buoy of each of three pairs used in this part of the test program. The results of the program are published in a series. Technical Report R-246[1], the first in the series, described the application of protective coatings and the installation of a cathodic protection system. Subsequent reports[2,3,4,5] describe the condition of the buoys from the first through the fourth rating inspections and the condition of the panels through their third rating inspection. This report describes the condition of the buoys at the time of their fifth rating inspection and the condition of the panels after 2 years of exposure.

SERVICE CONDITIONS

For the test, fifteen mooring buoys were placed in an area of North San Diego Bay that receives heavy service from the fleet. Some of the buoys were badly damaged by overriding vessels and by the abrasion of mooring lines and securing assemblies. Because it was necessary to place the test buoys in service a few at a time, and because there were long delays in obtaining acceptable specification coatings, placement required a long time. One set of thirteen panels was suspended from a pier in San Diego Bay and the other from a pier in Port Hueneme Harbor. A portion of each panel was continually submerged, another portion was intermittently submerged by rising tide, and a third portion was continually exposed to the atmosphere. The panels were not exposed to their harbor environments at the same time as the buoys. They were kept in storage until all of them had been coated, and then were all placed in test position at the same time, rather than over a 6-month period as were the buoys. At the time of their fourth rating (described herein), they had been exposed for 2 years.

INSPECTION PROCEDURE

Each of the test mooring buoys was inspected after it had been lifted onto the deck of a floating crane. The amount of fouling was determined, the types of organisms were recorded, and fouling damage to the coating was noted. After the fouling was examined, the cone and splash zone of each buoy were washed with a high-pressure stream of sea water to remove the fouling and expose any coating damage. Two independent ratings of the condition of each buoy and its protective coating system were made in the atmospheric, splash, and submerged zones.

To determine the amount of additional potential produced on cathodically protected buoys, electrical potential measurements were made on buoys with and without cathodic protection. The coating deterioration and corrosion damage of the three cathodically protected buoys was compared to that of the control buoys.

Two independent ratings were also made of the condition of the coating systems on the steel test panels exposed in San Diego Bay and Port Hueneme Harbor. Fouling organisms were carefully removed from one side of each test panel with a wooden scraper and a stiff brush before rating the coating condition in the fouled area.

RATING CRITERIA

As far as possible, the methods of rating the coating on buoys and test panels were those published by the American Society for Testing and Materials.[6] These published methods define the conditions rated and give photographic reference standards. Thus, chalking, blistering, checking, cracking, flaking, erosion, and rusting were rated from 0 to 10 by ASTM methods D-659-44, D-714-56, D-660-44, D-661-44, D-772-47, D-662-44, and D-610-43, respectively. A rating of 10 usually describes a perfect condition, and a rating of 0 a completely deteriorated condition. Blistering frequency was rated as none (N), few (F), medium (M), medium dense (MD), or dense (D). Surface area covered by fouling (plant, animal, or combined fouling) was rated from 0 (100% covered) to 10 (0% covered). Color of the topcoat on the buoys was also rated from 0 to 10; 10 indicates pure white with no yellowing or other discoloration (except rust streaks from uncoated bolts), and 0 indicates a color unacceptable to the U. S. Coast Guard.

Frequency of use of buoys by the fleet was rated as light (0 to 2 days per week), medium (2 to 4 days per week), or heavy (4 to 7 days per week). Some of the buoys provide bow and stem moorings only and the rest provide either bow and stem or free-swinging moorings.

The overall condition of each buoy and its coating system was rated as excellent (in essentially the same condition as when first placed in service); good (very minor deterioration); fair (a significant amount of coating deterioration and/or rusting, but still in serviceable condition); and poor (coating deterioration and rusting serious enough to lead to an early removal from service).

The coating system on each test panel was given an overall rating from 0 (minimum protection) to 10 (maximum protection), depending upon both the condition of the entire coating system and the protection afforded to the steel. It was much easier to rate the overall coating conditions on the panels than on the buoys, because the panels were not abraded in mooring service.

CONDITION OF BUOY COATINGS

Table I describes each coating system. The overall ratings and lengths of service of buoys coatings are summarized in Table II. The proprietary sources of the coatings tested are listed in References 2 through 4. Ratings of specific conditions of coated test buoys are given in Appendix A.

Coating System 1: Urethane. The condition of the System 1 buoy was virtually unchanged on its top and cone since the last rating inspection, but there was considerable pinpoint corrosion on the side (Figure 1). This rusting had apparently been initiated by the numerous very small blisters present in this area.

The many patches of underwater-curing epoxy that had been applied to underwater abraded areas two years earlier were still adhering strongly to the steel despite the previously reported[3,4,5] lifting of the edges of some of these patches. The large epoxy patch applied at the time of the last inspection was still in excellent condition (Figure 2). The scrubbing of the coating surrounding the wirebrushed steel area before patching may have provided a better bonding surface for the outer edge of the patch than was present for the two-year patches.

The fouling on all test buoys was generally similar, but considerably less than that at the time of the last inspection. It was slightly greater on buoys nearer the entrance to San Diego Bay. Since the System 1 buoy was nearest the entrance, it had slightly more fouling than most of the others. Bryozoa and hydroids constituted most of the fouling, with green algae conspicuous in the splash zone. A few tunicates and barnacles were present, but most of these were dead. Mussels, sponges, and tube worms were also present to a minor extent. Although the relative amounts of these organisms had changed markedly since the last inspection, the species were unchanged from those previously reported.

There were several localized areas of Teredo damage on the lower wooden fender (Figure 3). An area of very light Limnoria damage was also noted .

Coating System 2: Epoxy. The condition of the Coating System 2 buoy (Figure 4) was essentially the same as that noted at the time of the previous inspection. The very slight rusting noted previously[5] was initiated by abrasion damage to the coating. There was galvanic corrosion on the nuts securing the lower fender in place, but no damage to the fender.

Table I. System Description and Coating Thickness

System		Primer			Additional Coats			Total Thickness (mils)
Number	Description	Type	Coats (No.)	Thickness (mils)	Type	Coats (No.)	Thickness (mils)	
1	Urethane	Urethane	1	2	Urethane	3	8	10
2	Epoxy	Epoxy	1	4-5	Epoxy Epoxy Antifouling	1 1 1	4 3 4	8-9 11-12 15-16
3	Epoxy Polyester	Epoxy	1	4-5	Polyester Antifouling	2 1	5-6 4	9-11 13-15
[illegible]	Epoxy - Coal Tar Epoxy	Epoxy	1	4	Coal Tar Epoxy Epoxy Epoxy	1 1 1	4-5 4 4	8-9 12-13 16-17
5	Coal Tar Epoxy - Phenolic	Coal Tar Epoxy	1	5	Phenolic Phenolic	1 1	4-6 6-7	9-11 15-18
6 & 6C	Phenolic Mastic	Mica-filled Phenolic	1	10-11	Phenolic Mastic	1	8-9	18-20
7C	Phenolic	Wush Primer Phenolic	1 2	½ 4½	Phenolic Antifouling	1 1	2-3 3	7-8 8
8	Phenolic Alkyd	Wash Primer Phenolic	1 2	½ [illegible]	Alkyd Antifouling	1 1	2-3 3	7-8 8
9	Vinyl	Wash Primer Vinyl	1 4	½ 6½-7½	Vinyl-alkyd Antifouling	3 2	4 4	11-12 11-12
10	High-Body Vinyl	Vinyl	1	2	Vinyl Vinyl	2 1	5-6 2	7-8 9-10
11	Vinyl Mastic	Vinyl Phenolic	1	1-2	Vinyl Mastic	2	12-13	13-15
12	Inorganic Zinc Silicate- Vinyl Mastic	Inorganic Zinc Silicate Vinyl Phenolic	1 1	4 1-2	Vinyl Mastic	1	5-6	10-12
13 & 13C	Saran (Formula 113 '54)	—	—	—	Saran	8	8	8

Table II. Overall Rating and Length of Service for Coated Buoys

Coating System		Length of Service (days)	Overall Rating
Number	Description		
1	Urethane	787	good-fair
2	Epoxy	747	good
3	Epoxy - Polyester	747	fair
4	Epoxy - Coal Tar Epoxy	787	good-fair
5	Coal Tar Epoxy - Phenolic	746	fair
6	Phenolic Mastic	745	good-fair
6C	Phenolic Mastic	746	good
7C	Phenolic	599	good-fair
8	Phenolic - Alkyd	600	good-fair
9	Vinyl	622	good
10	High-Body Vinyl	713	fair
11	Vinyl Mastic	—	removed from test
12	Inorganic Zinc Silicate - Vinyl Mastic	787	fair
13	Saran	746	good-fair
13C	Saran	753	good

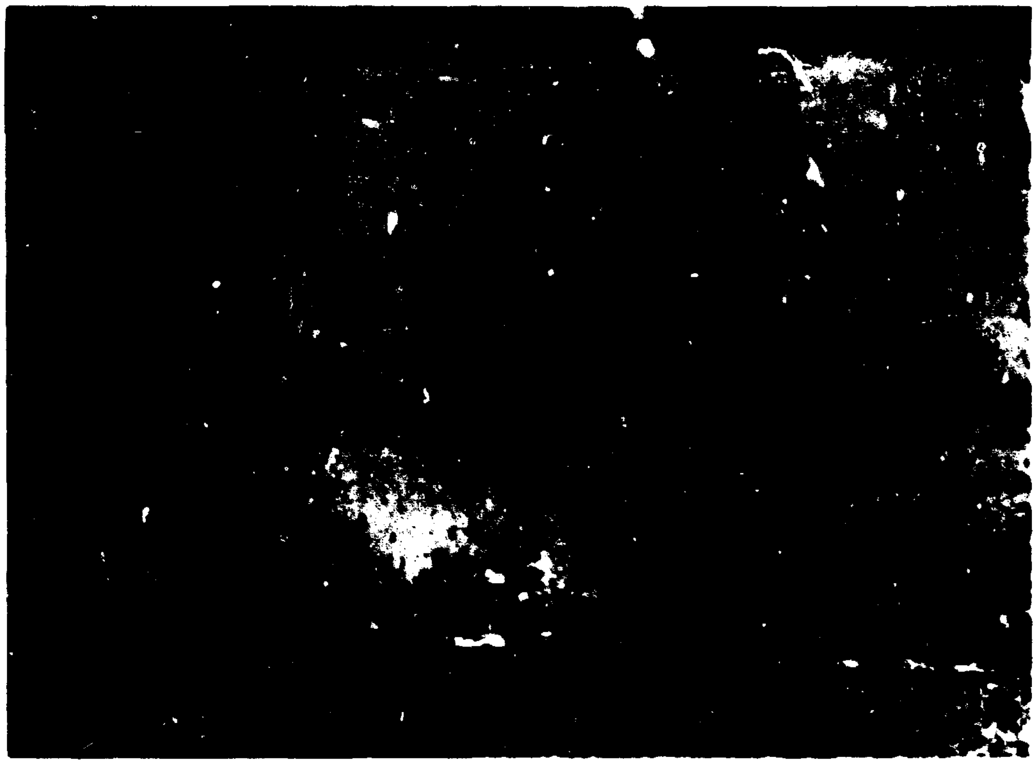

Figure 1. Pinpoint rusting on side of System 1 buoy.

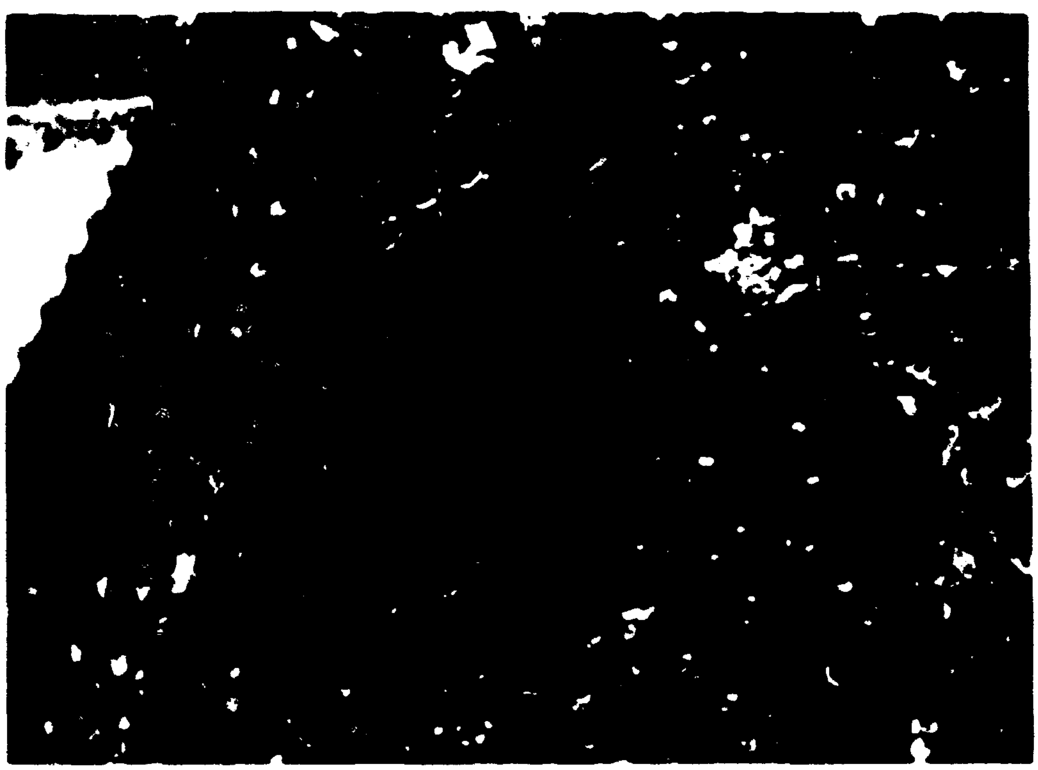

Figure 2. Epoxy patch on cone of System 1 buoy.

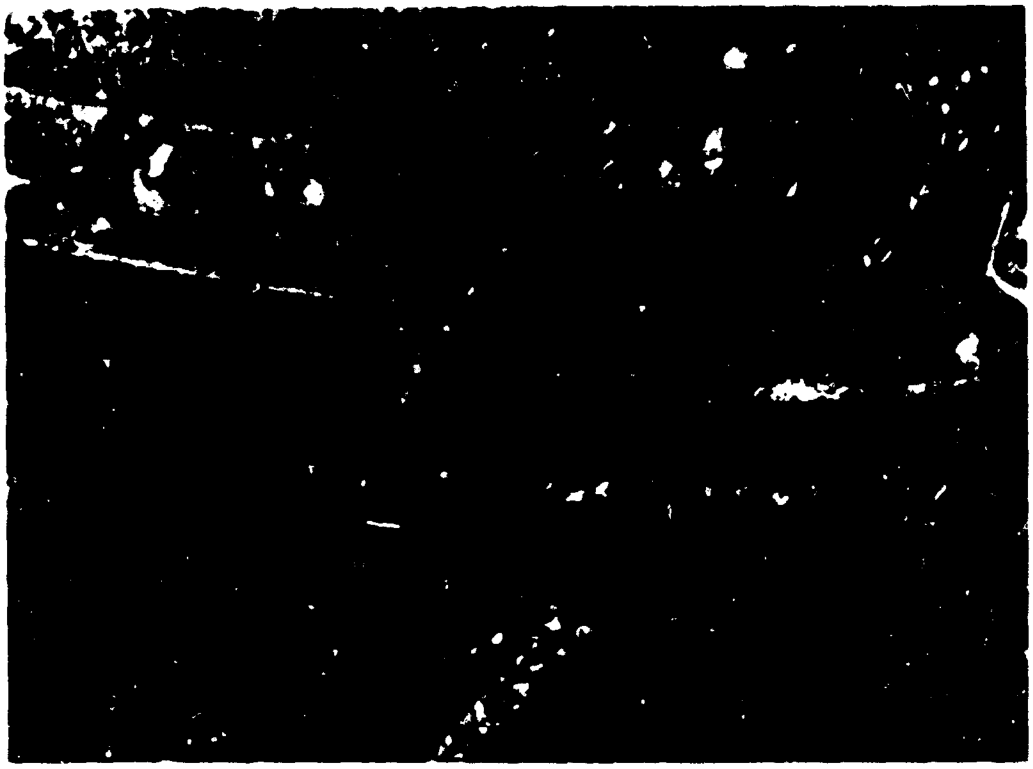

Figure 3. *Teredo* attack on lower fender of System 1 buoy.

Figure 4. System 2 buoy during removal of fouling.

Coating System 3: Epoxy-Polyester. The condition of the Coating System 3 buoy (Figure 5) was essentially the same as that noted at the time of the previous inspection. The epoxy primer exposed in the submerged zone, where some of the polyester topcoats had delaminated, was continuing to protect the underlying steel. The other slight coating damage in all three zones was related to abrasion. There was considerable localized Limnoria attack under the lower fender.

Coating System 4: Epoxy-Coal Tar Epoxy. The condition of the Coating System 4 buoy (Figure 6) was essentially the same as that noted at the time of the previous inspection. The previously reported delamination of the topcoat and seal coat in the submerged zone had not advanced significantly, and the underlying epoxy primer and coal tar epoxy were providing good protection to the steel.

Coating System 5: Coal Tar Epoxy-Phenolic. The condition of the Coating System 5 buoy (Figure 7) was essentially the same as that noted at the time of the previous inspection. There was considerable coating damage and rusting of steel on the buoy top caused by the abrasive action of the securing assembly. Lesser abrasion damage occurred on the buoy side and cone. A large portion of the epoxy patches on the buoy top had been lost by abrasion. The galvanic corrosion previously noted on abraded rivet heads in the submerged zone had not advanced significantly. There was slight Limnoria damage on the lower wooden fender.

Coating Systems 6 and 6C: Phenolic Mastic. Coating System 6 and 6C were identical, but the 6C coating was applied to a cathodically protected buoy. The condition of both buoys (Figure 8) was almost the same as that noted at the time of the previous inspection. The slight damage to both buoys had been caused by impact and abrasion of ships and mooring lines. The previously reported glavanic corrosion on the System 6 buoy had not advanced to any significant extent. The lower wooden fender on this buoy had slight Limnoria damage.

System 7C: Phenolic. The System 7C buoy (Figure 9) had slight abrasion damage on the top and side and slight pinpoint rusting on the side. There was a medium amount of very small blisters in the submerged zone. This accounted for some localized loss of coating. The cathodic protection had allowed only very light pinpoint rusting in these areas. Some localized loss of phenolic coating had occurred on the upper of the two flanges securing the lower fender in place (Figure 10). This loss may have taken place during the high-pressure hosing to clean the buoy, since the exposed steel was free of corrosion. Because this area is above the waterline, it could not have been cathodically protected. The light fouling on the buoy was similar to that on buoys in this area without an antifouling paint.

System 8: Phenolic-Alkyd. The System 8 buoy (Figure 11) had abrasion damage on the top and both abrasion damage and pinpoint rusting on the side. In the submerged zone, there was a medium amount of very small blisters. This had resulted in some pinpoint corrosion and localized loss of coating (Figure 12). The light fouling on this buoy was similar to that on buoys in this area without an antifouling paint.

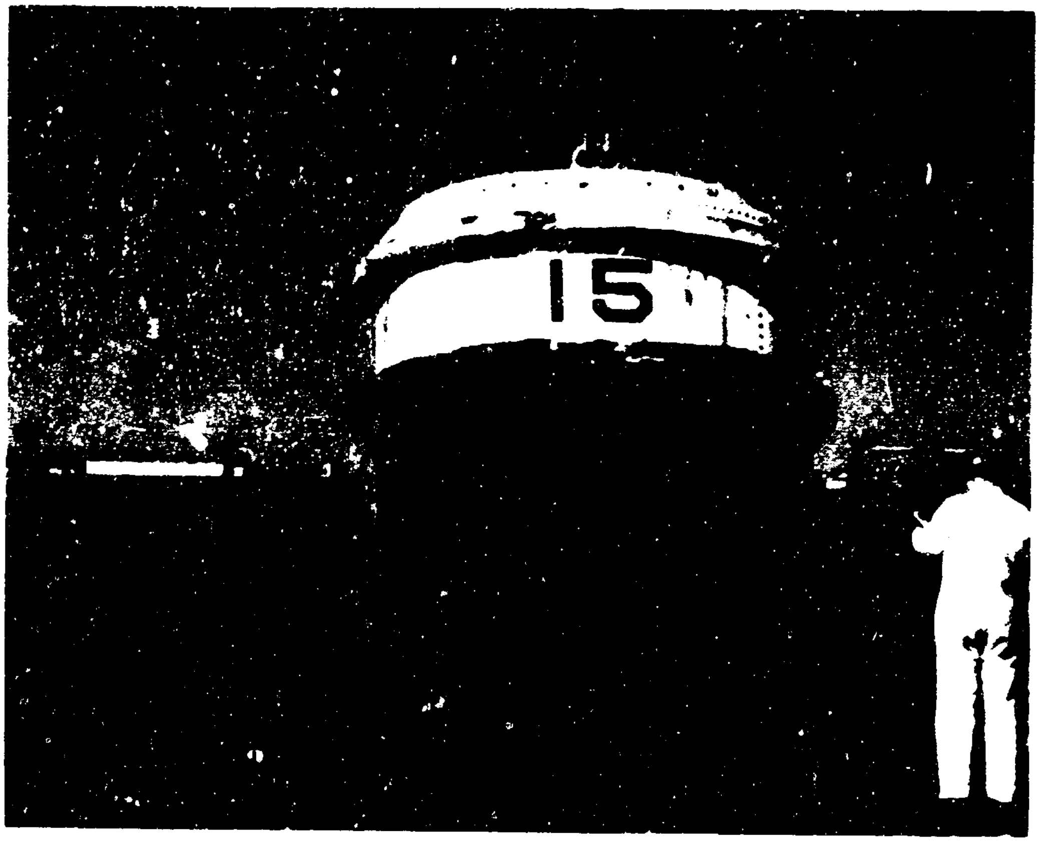

Figure 5. System 3 buoy before removal of fouling.

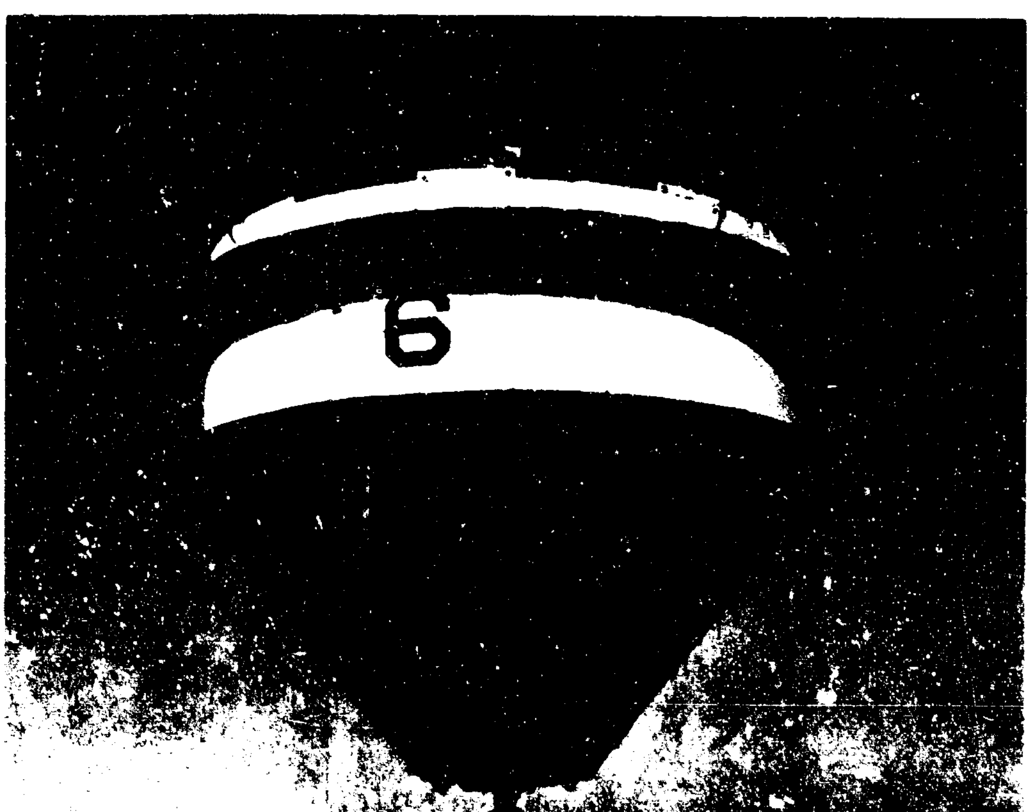

Figure 6. System 4 buoy showing delamination of seal and topcoats in submerged zone.

Figure 7. System 5 buoy before removal of fouling.

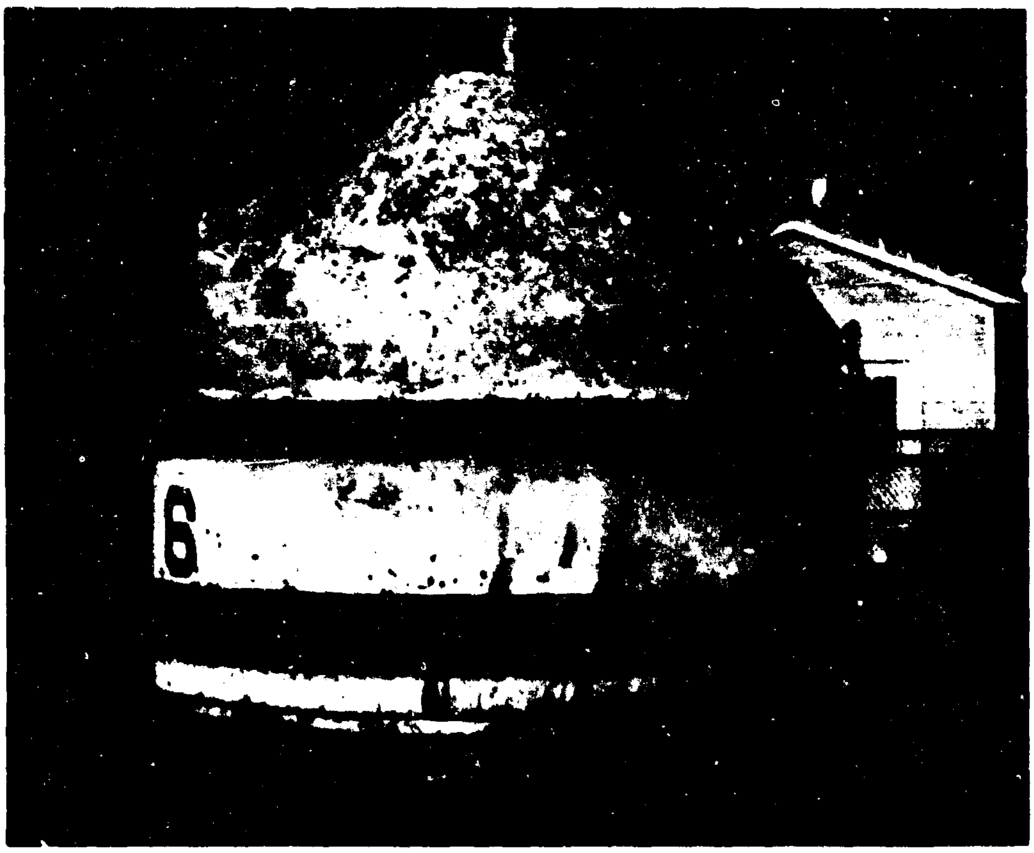

Figure 8. System 6C buoy ashore during relocation.

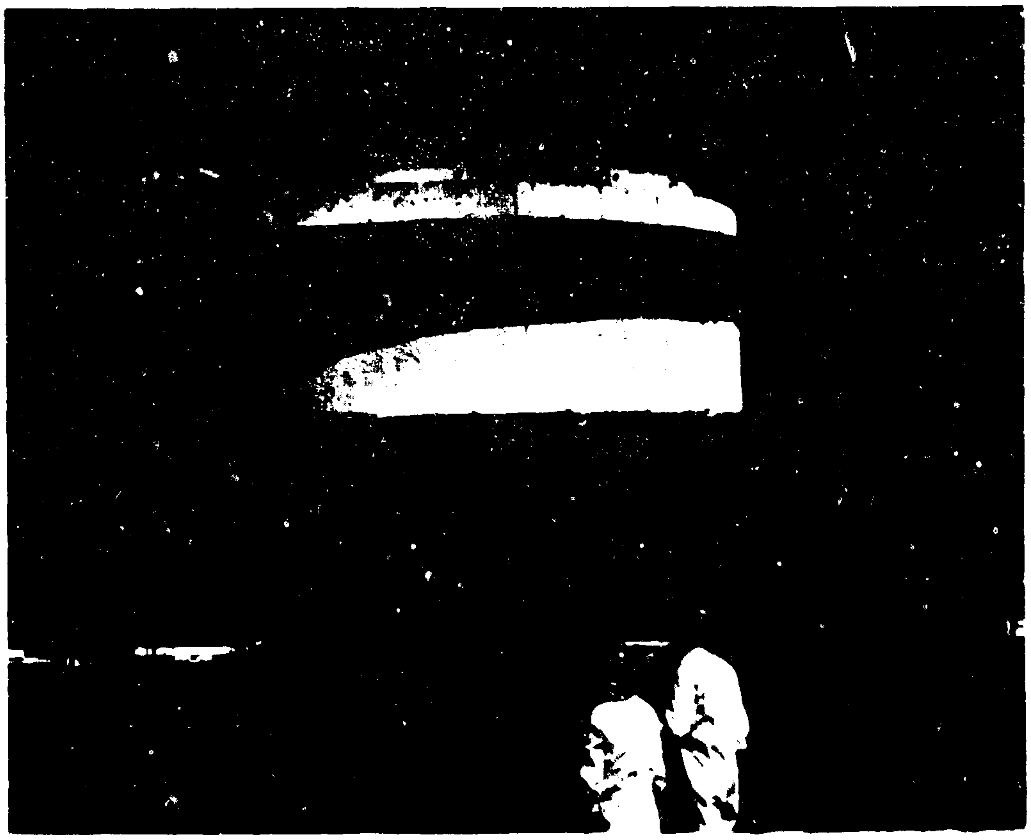

Figure 9. System 7C buoy with zinc anode on cone.

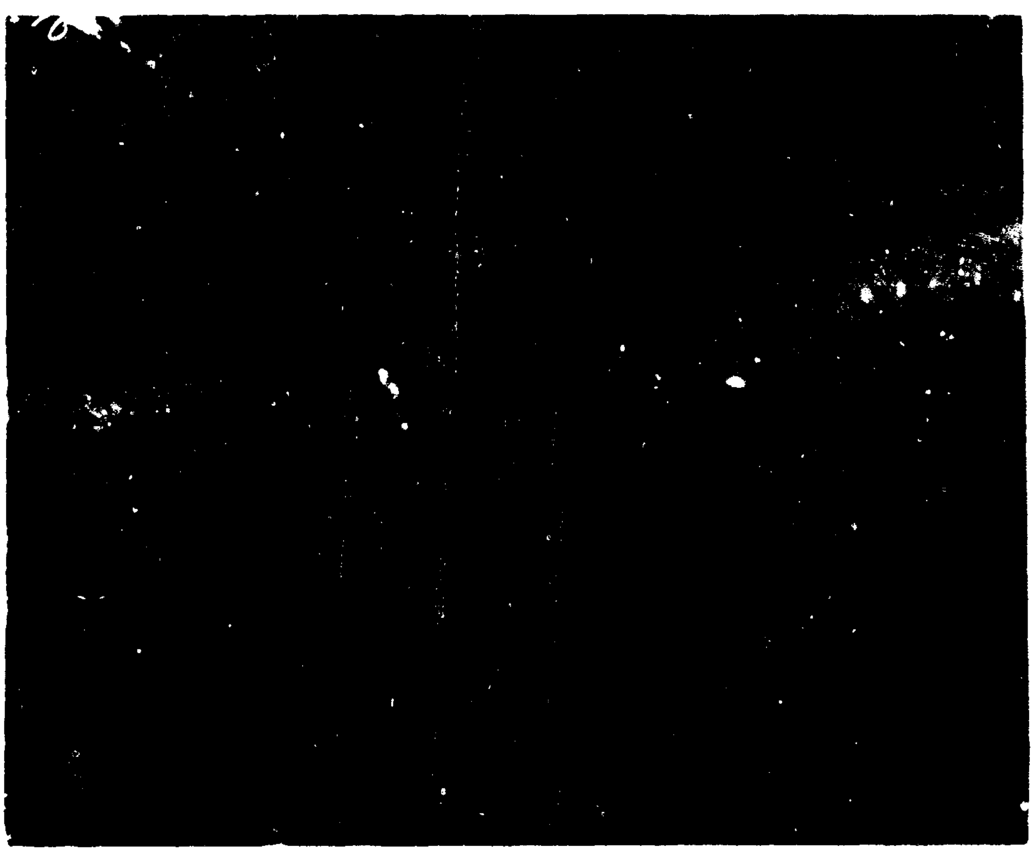

Figure 10. Flange above lower fender of System 7C buoy with localized loss of paint.

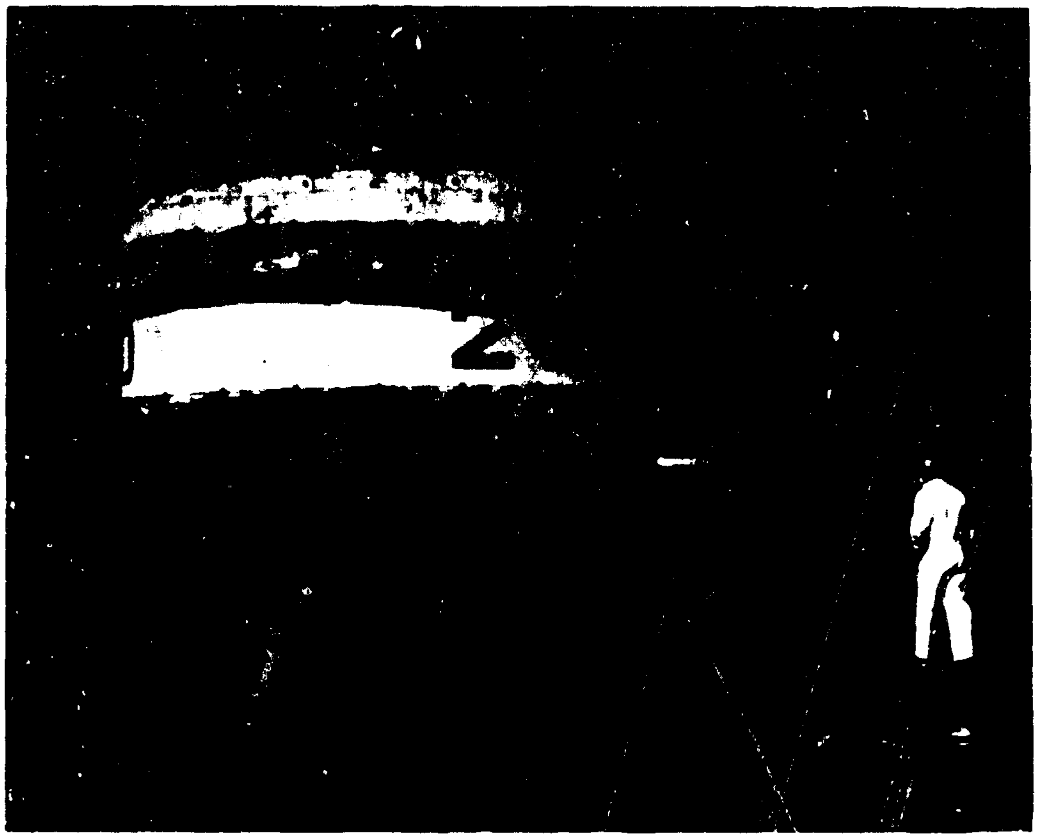

Figure 11. System 8 buoy before removal of fouling. Compare the amount of fouling to that on the buoys in Figures 5 and 15, which were located in the same general area.

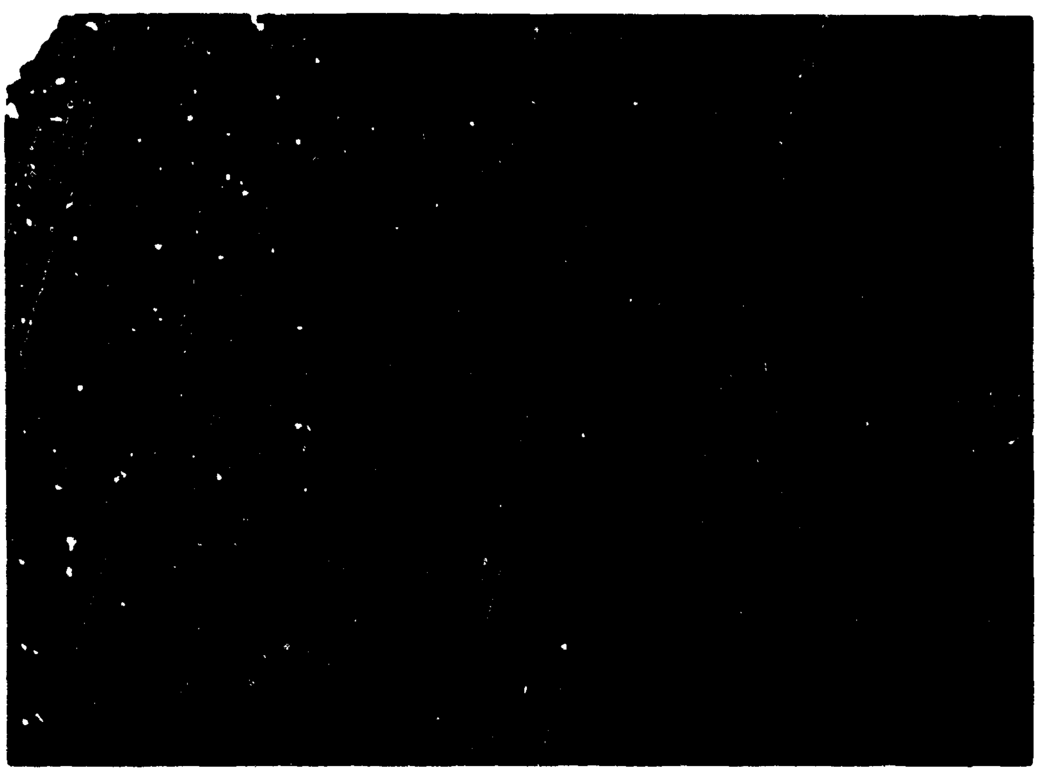

Figure 12. Localized loss of coating from cone of System 8 buoy.

System 9: Vinyl. The condition of the System 9 buoy (Figure 13) was essentially the same as that noted at the time of the previous inspection. The very slight coating damage previously reported was caused by abrasion. The antifouling coating had eroded in the submerged zone, exposing the primer in several places. The light fouling on this buoy was similar to that on buoys in this area without an antifouling paint. There was extensive localized Limnoria attack on the lower wooden fender (Figure 14).

System 10: High-Body Vinyl. The condition of the System 10 buoy (Figure 15) had deteriorated only slightly from that noted at the time of the previous inspection. There was abrasion damage on the top and pinpoint rusting (Figure 16) and blistering on the side. In the submerged zone, there was some rusting initiated by abrasion and some galvanic corrosion of abraded rivet heads.

System 11: Vinyl Mastic. Because of advanced corrosion, the Coating System 11 buoy was removed from testing one year ago.

System 12: Inorganic Zinc Silicate - Vinyl Mastic. The condition of the System 12 buoy (Figure 17) had changed little since the last inspection. There was very little rusting on the top and side, all caused by abrasion. In the submerged zone, about half of the primer and topcoat had been lost after 6 months of service. Two years later, the exposed inorganic zinc silicate was still preventing corrosion. There was relatively little fouling on this coating as compared to that on the topcoat.

Coating Systems 13 and 13C: Saran. Coating Systems 13 and 13C were identical, but System 13C was applied to a cathodically protected buoy. The System 13 buoy had extensive abrasion damage on the top caused by securing assembly (Figure 18). Part of the epoxy patches on the top had also been removed by abrasion. There was slight abrasion damage on the side and slight pinpoint rusting on the side and cone. There was galvanic corrosion on the nuts securing the lower fender in place.

The System 13C buoy (Figure 19) was in about the same condition as that noted at the time of the last inspection. There was slight abrasion damage and rusting on the top and side but none below the waterline. The better fendering system of this Mark II buoy and its cathodic protection system had provided much better protection than was received by the Mark I System 13 buoy.

CONDITION OF COATED PANELS

The coating system of each panel is rated in Table III, and the ratings of specific conditions are given in Appendix B.

There was a significant change in the type of fouling at both panel-exposure locations. At Port Hueneme, there was an increase in the number and size of mussels attached to the panels. At San Diego, none of the small shrimp so numerous at the time of the last inspection were present. The amount of tunicate fouling had diminished somewhat (Figure 20), but was considerably greater than that on the test buoys at the opposite end of San Diego Bay. A significant number of sponges were present on the San Diego panels for the first time.

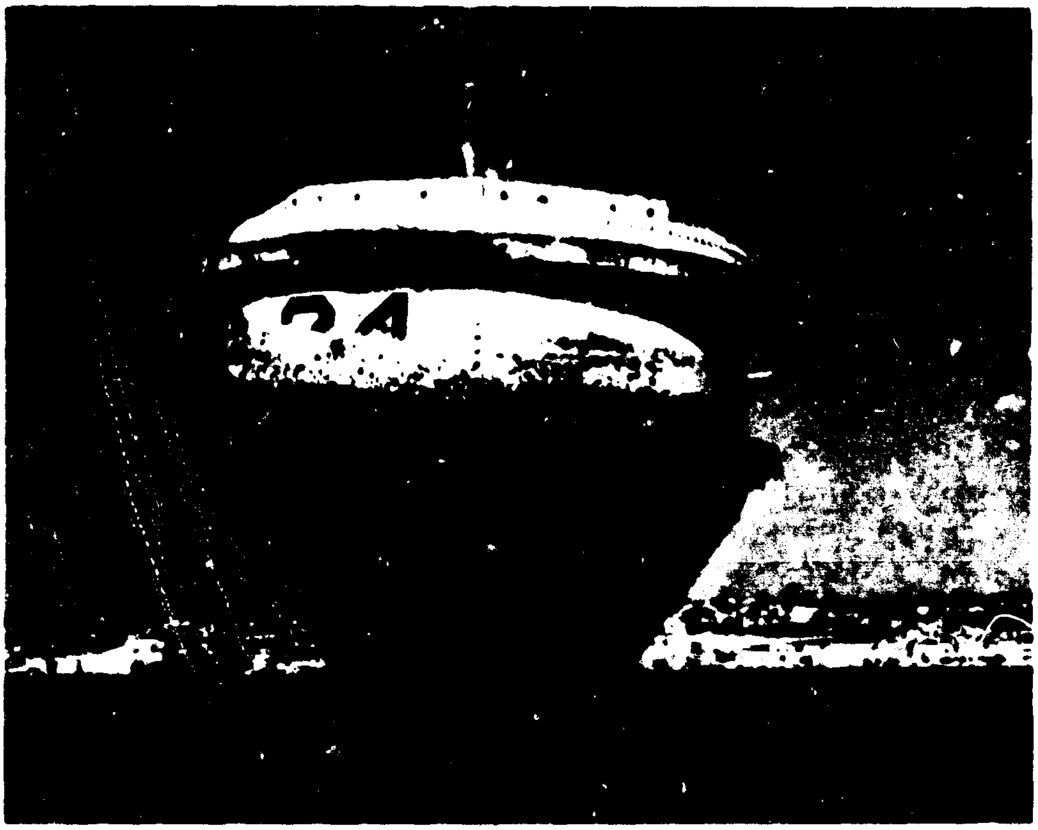

Figure 13. System 9 buoy after removal of fouling.

Figure 14. Limnoria attack on lower fender of System 9 buoy.

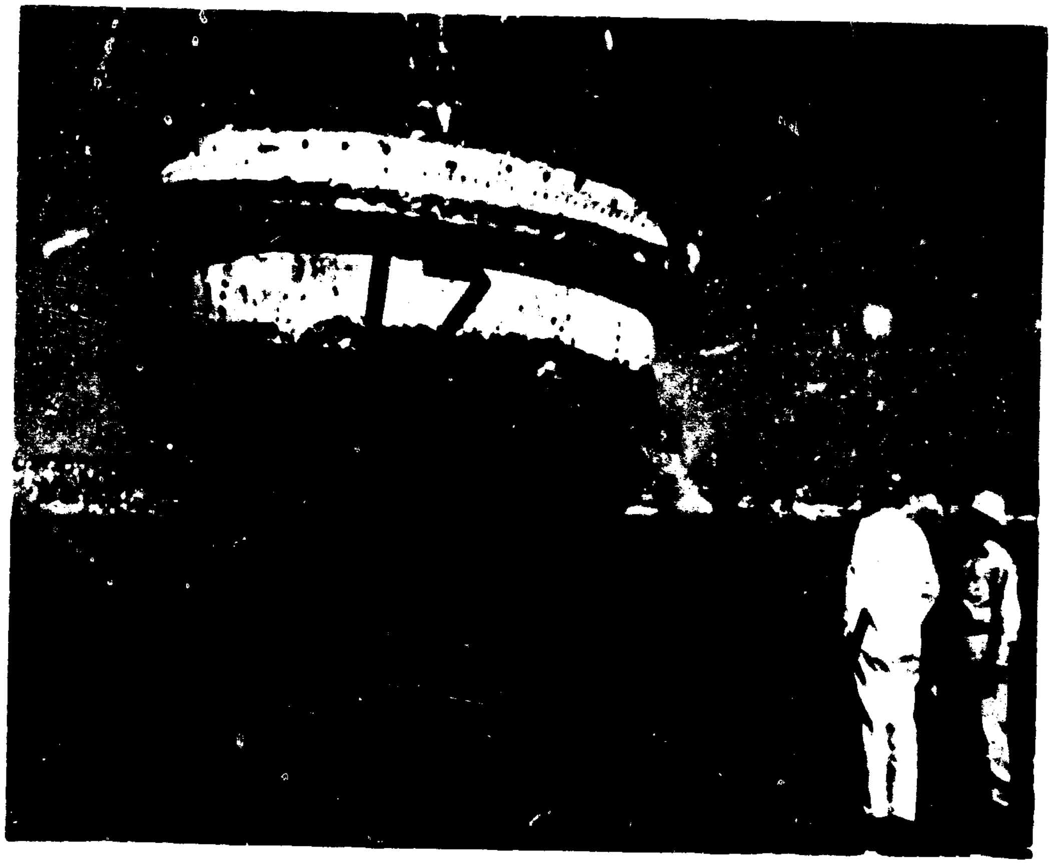

Figure 15. System 10 buoy before removal of fouling.

Figure 16. Pinpoint rusting on side of System 10 buoy.

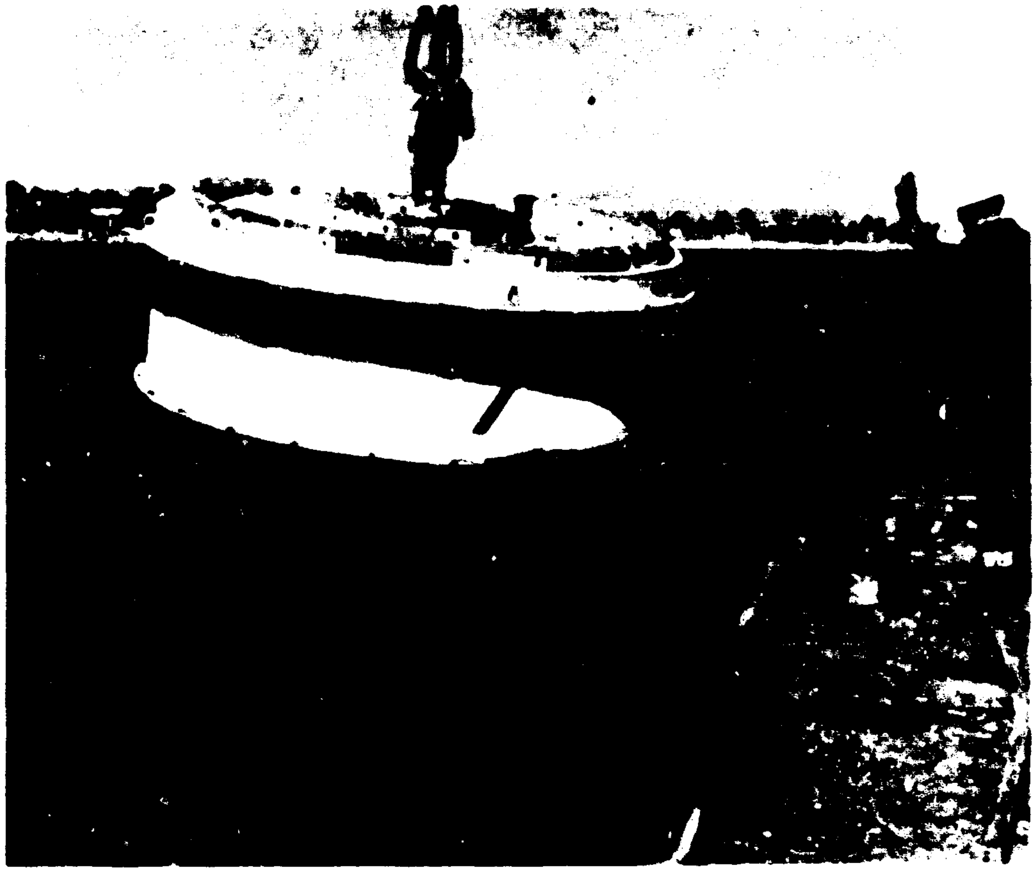

Figure 17. System 12 buoy on which fouling had been previously removed during relocation.

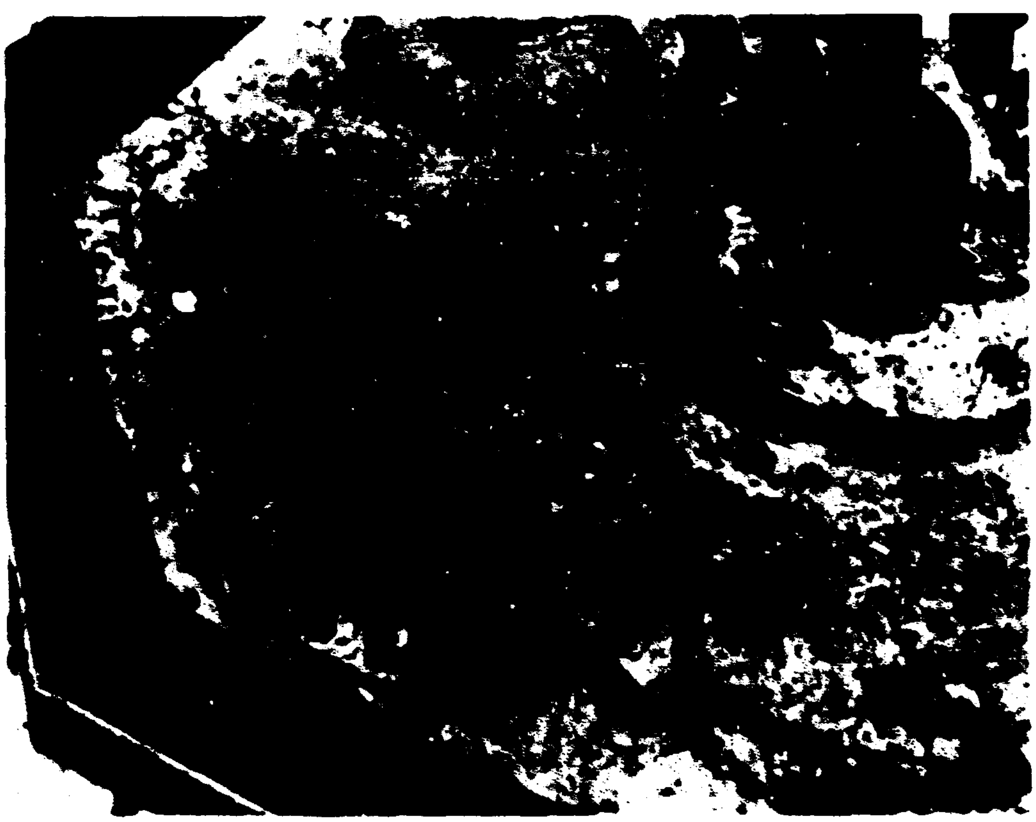

Figure 18. Abraded top of System 13 buoy.

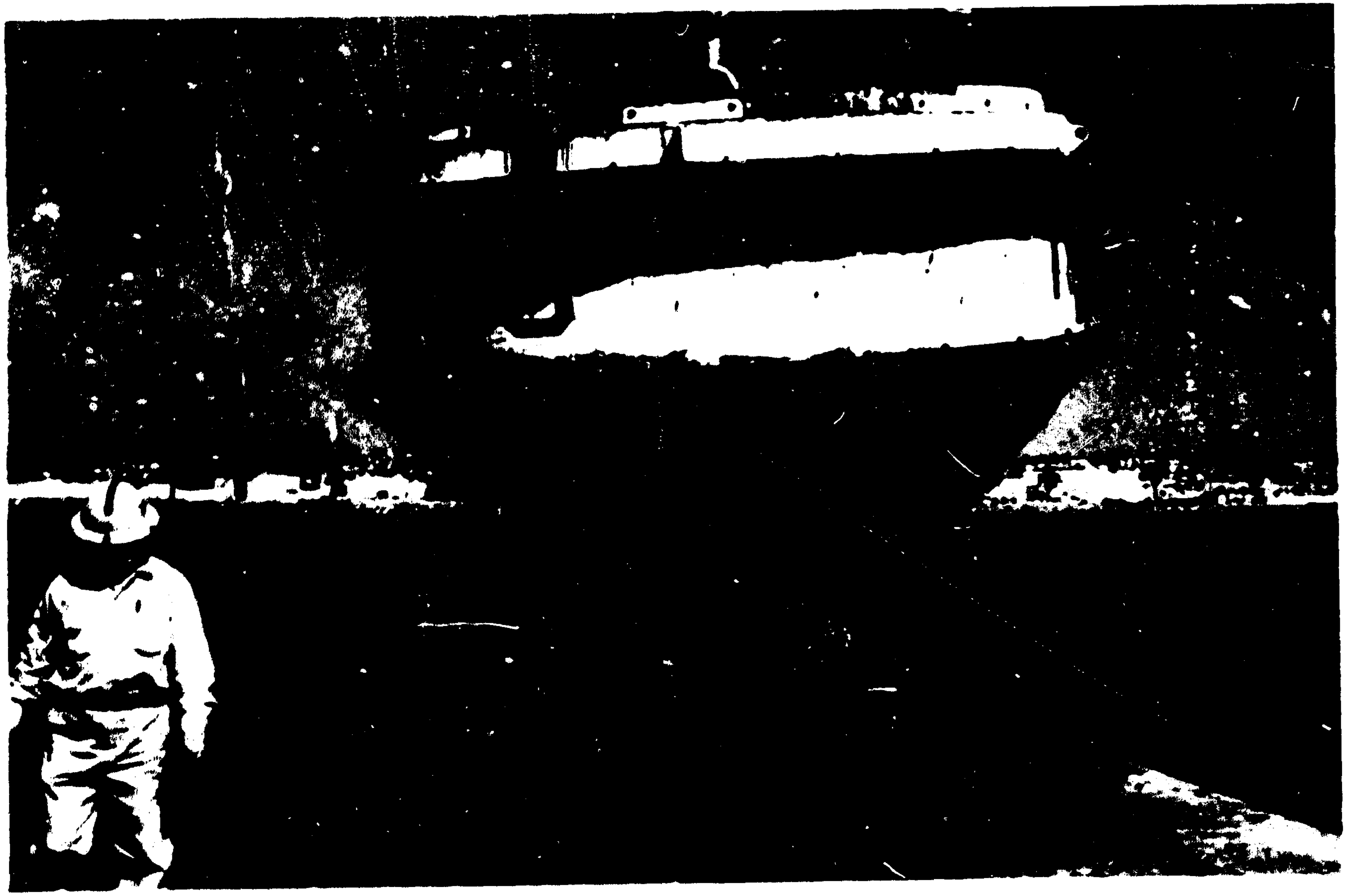

Figure 19. System 13C buoy after removal of fouling.

Table III. Overall Ratings of Coated Panels After Eighteen Months Exposure

Coating System		Ratings [1]	
Number	Description	Port Hueneme	San Diego
1	Urethane	9	9
2	Epoxy	10	10
3	Epoxy - Polyester	9	9
4	Epoxy - Coal Tar Epoxy	10	10
5	Coal Tar Epoxy - Phenolic	9	9
6	Phenolic Mastic	10	10
7C	Phenolic	10	10
8	Phenolic - Alkyd	10	10
9	Vinyl	10	10
10	High-Body Vinyl	8	9
11	Vinyl Mastic	7	8
12	Inorganic Zinc Silicate - Vinyl Mastic	9	9
13	Saran	9	9

[1] 10 = perfect condition; 0 = complete deterioration

Coating System 1: Urethane. Both urethane-coated panels were in relatively good condition. There was slight delamination of the topcoats in the tidal zone, slight rusting in these areas of delamination, and slight edge and pinpoint rusting in the atmospheric zone.

Coating System 2: Epoxy. Both panels with Coating System 2 were receiving excellent protection, and no deterioration other than the previously reported loss of the antifouling paint was noted.

Coating System 3: Epoxy-Polyester. As previously reported,[4,5] when the antifouling coat (identical to that of the System 2) was lost from the System 3 panels, it took the polyester coats with it, exposing the underlying epoxy primer. This primer has continued to prevent rusting on the San Diego panel and has permitted only slight rusting on the Port Hueneme panel. There is still no blistering on the San Diego panel, whereas there is still extensive blistering on the Port Hueneme panel.

Coating System 4: Epoxy-Coal Tar Epoxy. Neither of the System 4 panels showed deterioration in any zone.

Coating System 5: Coal Tar Epoxy-Phenolic. On both System 5 panels, there was extensive loss of the topcoat, exposing the underlying seal coat in the tidal and submerged zones. There was no topcoat remaining in these zones on the San Diego panel. The seal coat and primer, however, provided excellent protection from corrosion, and there was no rusting in any area on these panels.

Coating System 6: Phenolic Mastic. Neither of the System 6 panels showed deterioration in any zone.

Coating System 7C: Phenolic. The slight rusting previously reported[3,4,5] in the atmospheric zone of the Port Hueneme System 7C panel had not increased significantly. The San Diego panel had slight blistering of the antifouling paint and slight rusting associated with these very small blisters in the tidal zone. The antifouling coating was still effective in restricting the fouling to a light growth, but a slight amount of yellow primer was showing through the partially eroded black antifouling paint on both panels.

Coating System 8: Phenolic-Alkyd. On both System 8 panels there were a few small blisters in the tidal zone. There was no rusting on the Port Hueneme panel and only slight edge rusting on the San Diego panel. The antifouling paint was identical to that on the 7C panel, and the fouling was light on both System 7C and both System 8 panels. The System 8 panels also had some yellow primer showing through the partially eroded black antifouling paint.

Coating System 9: Vinyl. Neither System 9 panel showed deterioration in any zone, except for a partial erosion of the antifouling paint, which exposed some of the underlying primer. There was no rusting on either panel and only light fouling.

Coating System 10: High-Body Vinyl. There was blistering and rusting in all three zones of the Port Hueneme System 10 panel. Blistering was restricted to the tidal and submerged zones on the San Diego panels, and rusting in all zones was less than on the Port Hueneme panel.

Coating System 11: Vinyl Mastic. On the Port Hueneme System 11 panel, blistering and rusting were severe in the tidal zones, but the other zones were in comparatively good condition. The blistering and rusting on the San Diego panel was somewhat less severe than on the Port Hueneme panel.

Coating System 12: Inorganic Zinc Silicate - Vinyl Mastic. On the Port Hueneme panel, there were a considerable number of large blisters in the tidal zone, where 60% of the vinyl mastic coating had been lost. On the San Diego panel (Figure 21), no blisters could be found in the tidal and submerged zones, where 75% of the vinyl mastic coating had been lost. On both panels, the exposed inorganic zinc silicate had prevented corrosion, and there was no rusting in any zone.

Coating System 13: Saran. Both System 13 panels were in good condition. The only corrosion present consisted of slight pinpoint and edge rusting.

CATHODIC PROTECTION RESULTS

At the time of the last buoy inspection, the System 6C and 13C buoys had their cathodic protection systems modified to accept a zinc anode. The System 7C buoy had been similarly modified 132 days earlier and was providing complete protection to the underwater portion of the buoy.

At the time of the present inspection, the potential on the System 7C and 13C buoys was -850 mv. The System 6C buoy had been temporarily removed from service at the time of the present inspection for relocation of the mooring. When examined one month earlier, it had a potential of -760 mv with a ship secured to it and a potential of -810 mv one-half hour after the ship had left the mooring. The potential of buoys in the area without cathodic protection was -655 mv.

The square of bare steel (Figure 22) previously exposed on the cone of the System 13C buoy by wire brushing[3,4,5] was free of rust, giving evidence of complete protection. There was a loose, yellowish film on the zinc anodes. This was easily removed by hosing, and the underlying zinc surface was clean and crystalline. The condition of the loose film and underlying zinc is normal for properly functioning anodes, and no sign of passivation was noted. Relatively little of the anode had been lost in protecting the steel buoy, and the system should continue to provide complete protection for a long time before anode replacement will be necessary.

Figure 20. Test panel at San Diego showing rather heavy tunicate fouling at bottom.

Figure 21. System 12 panel at San Diego showing extensive loss of vinyl mastic coating but no corrosion.

Figure 22. System 13C showing uncorroded square of bare steel (see arrow) at left of zinc anode.

DISCUSSION

The condition of the buoy-coating systems at the time of each inspection is summarized in Table IV. At the time of the present inspection, Systems 2 (epoxy) and 9 (vinyl) were in the best condition. The antifouling paint on System 9 had eroded to the extent that it was no longer retarding fouling to any significant degree, and the underlying primer was showing in many places; however, the overall system is still providing good protection to the steel. It is noteworthy that Coating System 2 and 9 are on Mark I buoys that receive considerably less protection from impact and abrasion with their lighter fendering system than do the Mark II buoys with their heavier fendering system.

Coating Systems 6 and 6C (phenolic mastic) are providing relatively good protection to buoys, but this hard, thick coating has suffered impact and abrasion damage from the ships utilizing the test moorings. The better condition of the System 6C buoy, compared to the System 6 buoy, is due to the heavier fendering and cathodic protection.

The black antifouling paint (MIL-P-19449) of Coating System 7C and 8 has begun to blister lightly on the test buoys. As with the vinyl antifouling paint of System 9, the MIL-P-19449 has eroded so that some of the underlying primer is exposed, and fouling is no longer retarded to any significant extent.

Table IV. Condition of Buoy Coatings at Time of Each Inspection [1]

Coating System	0–6	6–12	12–18	18–24	24–30	30+
1		G	G	G	G	G-F
2	G	G	G		G, G	
3	G	F	F		F, F	
4		G	G-F	G-F	G-F	G-F
5	G	G-F	F		F, F	
6	G	G	G		G, G-F	
6C	G	G	G		G, G	
7C	G	G	G	G	G-F	
8	E	G	G	G, G-F		
9	E	E	G	G	G	
10	G	F	F	F	F	
11		P	P	P [2]		
12		F	F	F	F	F
13	G	G-F	G-F	G-F	G-F	
13C	G	G	G		G, G	

Cumulative Time (months): 6, 12, 18, 24, 30

[1] Ratings:
E = excellent
G = good
F = fair
P = poor

[2] Removed after 19 months

Coating System 1 (urethane) is in good condition in the submerged zone, where the patches of underwater-curing epoxy continue to protect the areas that received severe abrasion damage during the first six months of service. Slight blistering and pinpoint rusting on the side of the buoy has started since the time of the previous inspection.

Coating Systems 13 and 13C (saran) continue to provide good protection for test buoys, except for slight pinpoint rusting and abrasion damage. Again, the better condition of the System 13C buoy, compared to the System 13 buoy, is due to cathodic protection.

Coating System 4 (epoxy - coal tar epoxy) continues to provide good protection to the steel buoy in spite of delamination of 40% of the epoxy seal coat and topcoat in the submerged zone. The exposed epoxy primer and coal tar epoxy are providing excellent protection. Similarly, the zinc chromate-pigmented primer of System 3 (epoxy-polyester) is providing excellent protection in the submerged area, where much of the polyester topcoat has delaminated.

Coating System 5 (coal tar epoxy - phenolic) continues to provide fair protection to its buoy despite significant abrasion damage.

The loss of a large portion of the vinyl mastic coating from the submerged portion of the System 12 buoys did not result in corrosion because of the excellent protection afforded by the underlying inorganic zinc silicate. There is probably less rusting on this buoy than any other of the test buoys. Although the coating condition is rated as fair, it is actually providing as good protection to the buoys as any of the coatings. If the topcoat had not delaminated in the submerged zone, the service life of this coating might have turned out to be extremely long. The sacrificial effect of the exposed 4-mil coat of inorganic zinc silicate cannot be expected to continue for very many years.

The poorer service of the high-body vinyl system (Coating System 10), compared to the vinyl system (Coating System 9), has resulted from the blistering that initiated coating deterioration and rusting.

Significant damage to the lower wooden fender on many of the Mark I buoys by marine boring organisms was first noted during the present inspection. Attack by <u>Limnoria</u> appeared to be more widespread than <u>Teredo</u> attack. There was no attack on the lower fenders of Mark II buoys, because they were located above the waterline.

The condition of identically coated panels exposed at Port Hueneme and San Diego was generally quite similar despite differences in environment. The antifouling paints on Systems 7C, 8, and 9 are still effective in reducing the amount of fouling. The longer effectiveness of these paints on panels than on buoys is no doubt due to the fact that the panels were located in quiet areas, while the buoys were located where strong currents leach the toxicants more rapidly.

The zinc anodes on the three cathodically protected buoys were fully protecting the buoys. No evidence was found of passivation of the zinc, as previously noted in San Diego Bay by Peterson and Waldron[7] in earlier work.

FINDINGS

1. On four of the test buoys, the coating systems were in good condition; ten showed varying degrees of intermediate deterioration.

2. The antifouling coats on test panels were still effective in retarding fouling after two years, while on test buoys they had lost most of their effectiveness after 20 months.

3. The previously noted galvanic corrosion of rivet heads had not increased significantly.

4. Significant marine borer damage to the lower wooden fender of Mark I buoys was noted for the first time.

5. The zinc anodes on the three cathodically protected buoys were providing complete protection to the underwater portion of these buoys.

ACKNOWLEDGMENT

Mr. A. F. Curry of NCEL made an independent rating of the coated buoys and both sets of coated panels.

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Appendix A

RATINGS OF BUOYS WITH TEST COATINGS

Coating System 1: Urethane

No. of Days in Service: 942

Overall Condition: Good-Fair

Amount of use: Heavy

Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	4	4	–
Blistering	N, 10	M, 8	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I [1]	9	9	9
Rusting, Type II [2]	10	10	10
Fouling, amount	–	medium	medium
Guano, amount	light	–	–
Structural damage	none	none	dent in steel plate

[1] Without blistering.
[2] With blistering.

Coating System 2: Epoxy

No of Days in Service: 901

Overall Condition: Good

Amount of use: Heavy

Type of Mooring: Bow and Stern

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	–
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	9	10	9
Rusting, Type II	10	10	10
Fouling, amount	–	light	light
Guano, amount	medium	–	–
Structural damage	none	none	dent in steel plate

Coating System 3: Epoxy - Polyester

No. of Days in Service: 900 Overall Condition: Fair

Amount of use: Heavy Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	5 [1]	5 [1]
Erosion	10	10	10
Rusting, Type I	9	9	9
Rusting, Type II	10	10	10
Fouling, amount	–	light	light
Guano, amount	medium	–	–
Structural damage	fender splintered	none	fender splintered

[1] Topcoat lost exposing primer.

Coating System 4: Epoxy - Coal Tar Epoxy

No. of Days in Service: 943

Overall Condition: Good-Fair

Amount of use: Heavy

Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	8	8	—
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	6 [1]
Erosion	10	10	10
Rusting, Type I	9	9	10
Rusting, Type II	10	10	10
Fouling, amount	—	light	light
Guano, amount	light	—	—
Structural damage	none	none	none

[1] Delamination of topcoat and seal coat, exposing coal tar epoxy coating.

Coating System 5: Coal Tar Epoxy-Phenolic

No. of Days in Service: 901

Overall Condition: Fair

Amount of use: Light

Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	7	9	9 [1]
Rusting, Type II	10	10	10
Fouling, amount	–	medium	medium
Guano, amount	light	–	–
Structural damage	none	none	dent in steel plate

[1] Rivet heads were badly corroded.

Coating System 6: Phenolic Mastic

No. of Days in Service: 901

Overall Condition: Good

Amount of use: Light

Type of Mooring: Bow and Stern

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	8	8	—
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	8	9	9[1]
Rusting, Type II	10	10	10
Fouling, amount	—	medium	medium
Guano, amount	light	—	—
Structural damage	dent in side; broken fender	broken fender	dent in steel plate

[1]Rivet heads were badly corroded.

Coating System 6C: Phenolic Mastic

No. of Days in Service: 900

Overall Condition: Good

Amount of use: Light

Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	6	6	—
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	8	9	9
Rusting, Type II	10	10	10
Fouling, amount	—	light	medium
Guano, amount	light	—	—
Structural damage	fender splintered	none	none

Coating System 7C: Phenolic

No. of Days in Service: 753

Overall Condition: Good-Fair

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	M, 8
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	9[1]	10
Erosion	10	10	8[2]
Rusting, Type I	9	9	9
Rusting, Type II	10	10	10
Fouling, amount	–	light	light
Guano, amount	medium	–	–
Structural damage	none	none	none

[1] A small patch of coating lost from fender flange.
[2] Antifouling paint only.

Coating System 8: Phenolic - Alkyd

No. of Days in Service: 753

Overall Condition: Good-Fair

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	M, 8
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	9
Erosion	10	10	9[1]
Rusting, Type I	8	9	9
Rusting, Type II	10	10	9
Fouling, amount	–	light	light
Guano, amount	light	–	–
Structural damage	none	none	none

[1] Antifouling paint only.

Coating System 9: Vinyl

No. of Days in Service: 775

Overall Condition: Good

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	10	–
Chalking	10	10	–
Blistering	N, 10	N, 10	N, 10
Checking	N, 10	10	10
Cracking	N, 10	10	10
Flaking (scaling)	N, 10	10	10
Erosion	N, 10	10	9[1]
Rusting, Type I	9	9	9
Rusting, Type II	10	10	10
Fouling, amount	–	light	light
Guano, amount	light	–	–
Structural damage	none	dent in steel plate	dent in steel plate

[1] Antifouling paint only.

Coating System 10: High-Body Vinyl

No. of Days in Service: 867

Overall Condition: Fair

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	F, 2	F, 2
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	8	8	9
Rusting, Type II	10	10	10
Fouling, amount	–	medium	light
Guano, amount	light	–	–
Structural damage	none	fender splintered	none

Coating System 12: Inorganic Zinc Silicate - Vinyl Mastic

No. of Days in Service: 943

Overall Condition: Fair

Amount of use: Heavy

Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	10	10	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	5 1/
Erosion	10	10	10
Rusting, Type I	9 2/	10	10
Rusting, Type II	10	10	10
Fouling, amount	–	light	medium
Guano, amount	light	–	–
Structural damage	none	none	none

1/Topcoat only
2/Top edge only

Coating System 13: Saran

No. of Days in Service: 901

Overall Condition: Good-Fair

Amount of use: Light

Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	9	9	8
Rusting, Type II	10	10	9
Fouling, amount	–	light	light
Guano, amount	light	–	–
Structural damage	none	fender splintered; dent in steel plate	none

Coating System 13C: Saran

No. of Days in Service: 907

Overall Condition: Good

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	9	9	10
Rusting, Type II	10	10	10
Fouling, amount	–	light	medium
Guano, amount	medium	–	–
Structural damage	dent in steel plate	dent in steel plate	none

Appendix B — RATING OF TEST PAN

Coating System No.	1						2								
Exposure Site	PH			SD			PH			SD			PH		
Panel Zone	A[1]	T[2]	S[3]	A	T	S	A	T	S	A	T	S	A	T	S
General Protection	8	9	10	9	9	10	10	10	10	10	10	10	9	9	10
Chalking	2	—	—	1[5]	—	—	4[4]	—	—	—	—	—	10	—	—
Checking	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Blistering, size	10	10	10	10	10	10	10	10	10	10	10	10	10	6	6
Blistering, frequency	N[5]	N	N	N	N	N	N	N	N	N	N	N	N	M[8]	M
Flaking	10	8[7]	10	10	8[7]	10	10	10	10	10	10	10	10	8[12]	8[12]
Cracking	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Undercutting	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Rusting, Type I	8[13]	9	10	8[8]	9	10	10	10	10	10	10	10	9	9	10
Rusting, Type II	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Pitting	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Fouling, amount	—	L[9]	L	—	M[8]	M	—	M	M	—	M	M	—	M	M
Fouling, area[10]	—	1	0	—	0	2	—	2	3	—	1	1	—	4	2
1. Plant Area	—	1	2	—	9	9	—	8	8	—	9	8	—	7	5
2. Animal Area	—	9	3	—	0	2	—	3	3	—	1	2	—	6	4
a. Tunicates	—	10	10	—	9	8	—	10	10	—	9	6	—	10	10
b. Barnacles	—	9	8	—	2	7	—	3	8	—	1	7	—	6	9
c. Mussels	—	10	3	—	10	9	—	7	9	—	10	10	—	9	10
d. Bryozoa	—	10	7	—	10	10	—	10	4	—	10	10	—	10	5
e. Hydroids	—	10	6	—	10	10	—	10	5	—	10	9	—	10	8
f. Tube Worms	—	10	5	—	10	9	—	10	7	—	10	10	—	10	7
g. Sponges	—	10	10	—	9	8	—	10	10	—	9	9	—	10	10
Overall Rating	9			10			10			10			9		

1/ A = atmospheric zone
2/ T = tidal zone
3/ S = submerged zone
4/ Antifouling top coat only
5/ N = none
6/ H = heavy
7/ Delamination of top-coats
8/ M = medium
9/ L = light
10/ 0 = 100% fouled; 10 = 0% fouled
11/ F = few
12/ Antifouling and top coat lost exposing

A

Appendix B – RATING OF TEST PANELS AT PORT HUENEME AND SAN DIEGO

1			2						3						4				
SD			PH			SD			PH			SD			PH			SD	
A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T
9	9	10	10	10	10	10	10	10	9	9	10	10	10	10	10	10	10	10	10
[15]	–	–	4[4]	–	–	–	–	–	10	–	–	–	–	–	10	–	–	–	–
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	6	6	10	10	10	10	10	10	10	10
N	N	N	N	N	N	N	N	N	N	M[8]	M	N	N	N	N	N	N	N	N
10	8[7]	10	10	10	10	10	10	10	10	6[12]	8[12]	10	1[12]	2[12]	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
8[8]	9	10	10	10	10	10	10	10	9	9	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
–	M[8]	M	–	M	M	–	M	M	–	M	M	–	M	M	–	M	M	–	M
–	0	2	–	2	3	–	1	1	–	4	2	–	2	1	–	2	1	–	3
–	9	9	–	8	8	–	9	8	–	7	5	–	9	8	–	9	7	–	9
–	0	2	–	3	3	–	1	2	–	6	4	–	2	2	–	2	2	–	3
–	9	8	–	10	10	–	9	6	–	10	10	–	9	8	–	10	9	–	9
–	2	7	–	3	8	–	1	7	–	6	9	–	2	7	–	2	8	–	3
–	10	9	–	7	9	–	10	10	–	9	10	–	10	9	–	6	8	–	10
–	10	10	–	10	4	–	10	10	–	10	5	–	10	10	–	10	3	–	10
–	10	10	–	10	5	–	10	9	–	10	8	–	10	9	–	10	8	–	10
–	10	9	–	10	7	–	10	10	–	10	7	–	10	10	–	10	5	–	10
–	9	8	–	10	10	–	9	9	–	10	10	–	9	8	–	10	10	–	9
	10			10			10			9			9			10			10

N – none
H – heavy
Delamination of top-coats
M = medium

9/ L light
10/ 0 100% fouled; 10 0% fouled
11/ F few
12/ Antifouling and top coat lost exposing primer

13/ A few pin holes only
14/ Delamination of primer and t
exposing zinc silicate coatin

B

PORT HUENEME AND SAN DIEGO

		4						5						6					
SD		PH			SD			PH			SD			PH			SD		
T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
—	—	10	—	—	—	—	—	10	—	—	—	—	—	10	—	—	—	—	—
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
1[12]	2[12]	10	10	10	10	10	10	10	2[16]	5[16]	10	0[16]	0[16]	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
M	M	—	M	M	—	M	H	—	H	H	—	M	M	—	M	M	—	M	M
2	1	—	2	1	—	3	2	—	1	1	—	1	1	—	2	2	—	1	1
9	8	—	9	7	—	9	7	—	8	8	—	9	8	—	9	8	—	9	8
2	2	—	2	2	—	3	2	—	1	1	—	1	2	—	2	2	—	1	2
9	8	—	10	9	—	9	8	—	10	10	—	9	7	—	10	10	—	9	8
2	7	—	2	8	—	3	9	—	1	9	—	1	3	—	2	9	—	1	7
10	9	—	6	8	—	10	9	—	9	7	—	9	9	—	9	8	—	10	9
10	10	—	10	3	—	10	10	—	10	5	—	10	10	—	10	8	—	10	10
10	9	—	10	8	—	10	10	—	10	6	—	10	9	—	10	6	—	10	9
10	10	—	10	5	—	10	10	—	10	7	—	10	10	—	10	6	—	10	10
9	8	—	10	10	—	9	7	—	10	10	—	9	8	—	10	10	—	9	8
9		10			10			9			9			10			10		

13/ A few pin holes only

14/ Delamination of primer and top coat exposing zinc silicate coating

15/ Impossible to determine chalking on San Diego panels because of extremely high tide at time of inspection

16/ Loss of top coat exposing gray seal coat

Continued

Coating System No.	7C						8						9				
Exposure Site	PH			SD			PH			SD			PH			SD	
Panel Zone	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T
General Protection	9	10	10	10	9	10	10	10	10	10	9	10	10	10	10	10	10
Chalking	8	—	—	—	—	—	4	—	—	—	—	—	10	—	—	—	—
Checking	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Blistering, size	10	10	10	10	10	10	10	10	8	10	10	8	10	10	10	10	10
Blistering, frequency	N	N	N	N	M	F[11]	N	N	F	N	N	F	N	N	N	N	N
Flaking	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Cracking	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Undercutting	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Rusting, Type I	9	10	10	10	10	10	10	10	10	10	9[6]	10	10	10	10	10	10
Rusting, Type II	10	10	10	10	9	10	10	10	10	10	10	10	10	10	10	10	10
Pitting	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Fouling, amount	—	L	L	—	L	L	—	L	L	—	L	L	—	L	L	—	L
Fouling, area[10]	—	5	4	—	5	5	—	3	2	—	5	5	—	3	1	—	5
1. Plant Area	—	5	5	—	9	7	—	3	2	—	9	7	—	3	1	—	7
2. Animal Area	—	9	[illegible]	—	5	8	—	9	9	—	5	8	—	9	10	—	6
a. Tunicates	—	10	10	—	9	[illegible]	—	10	10	—	9	9	—	10	10	—	10
b. Barnacles	—	9	9	—	5	9	—	9	9	—	5	9	—	9	10	—	7
c. Mussels	—	10	10	—	10	10	—	10	10	—	10	10	—	10	10	—	10
d. Bryozoa	—	10	9	—	10	10	—	10	10	—	10	10	—	10	10	—	10
e. Hydroids	—	10	10	—	10	9	—	10	10	—	10	9	—	10	10	—	10
f. Tube Worms	—	10	9	—	10	9	—	10	10	—	10	9	—	10	10	—	10
g. Sponges	—	10	10	—	9	9	—	10	10	—	10	9	—	10	10	—	10
Overall Rating	10			10			10			10			10			10	

1/ A = atmospheric zone
2/ T = tidal zone
3/ S = submerged zone
4/ Antifouling top coat only
5/ N = none
6/ H = heavy
7/ D = dense
8/ M = medium
9/ L = light
10/ 0 = 100% fouled; 10 = 0% fouled,
11/ F = few
12/ Antifouling and top coat lost expo

A

B — RATING OF TEST PANELS AT PORT HUENEME AND SAN DIEGO (Contd)

	9						10						11						12					
	PH			SD			PH			SD			PH			SD			PH			SD		
S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S
10	10	10	10	10	10	10	9	8	7	9	9	9	9	5	9	10	8	7	10	10	10	10	10	[illegible]
—	10	—	—	—	—	—	10	—	—	—	—	—	10	—	—	—	—	—	10	—	—	—	—	[illegible]
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	[illegible]
8	10	10	10	10	10	10	6	2	2	10	2	2	10	2	2	10	10	10	10	2	10	10	10	[illegible]
F	N	N	N	N	N	N	F	M	F	N	M	F	N	M	F	N	N	N	N	M	N	N	N	[illegible]
10	10	10	10	10	10	10	10	10	10	10	10	10	10	7	9	10	6	7	10	4 14/	10	10	2 14/	3 [illegible]
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	[illegible]
10	10	10	10	10	10	10	10	10	10	10	9	9	10	6	9	10	8	7	10	10	10	10	10	[illegible]
10	10	10	10	10	10	10	8	10	10	9	9	9	9	6	10	10	8	7	10	10	10	10	10	[illegible]
10	10	10	10	10	10	10	8	8	8	9	9	9	10	6	8	10	10	10	10	10	10	10	10	[illegible]
10	10	10	10	10	10	10	8	8	8	10	10	10	10	9	10	10	9	9	10	10	10	10	10	[illegible]
L	—	L	L	—	L	L	—	M	H	—	M	M	—	M	H	—	M	H	—	M	M	—	L	M
5	—	3	1	—	5	3	—	1	1	—	1	1	—	1	1	—	0	1	—	2	1	—	5	[illegible]
7	—	3	1	—	7	5	—	9	8	—	9	8	—	9	9	—	9	9	—	9	9	—	9	[illegible]
8	—	9	10	—	6	8	—	2	1	—	1	3	—	1	1	—	0	1	—	2	1	—	5	[illegible]
9	—	10	10	—	10	9	—	10	10	—	9	6	—	10	10	—	9	7	—	10	10	—	9	[illegible]
9	—	9	10	—	7	9	—	5	7	—	1	6	—	2	9	—	0	7	—	3	8	—	5	[illegible]
10	—	10	10	—	10	10	—	6	5	—	10	9	—	7	3	—	10	9	—	7	6	—	10	[illegible]
10	—	10	10	—	10	10	—	10	6	—	10	10	—	10	6	—	10	10	—	10	7	—	10	[illegible]
9	—	10	10	—	10	9	—	10	8	—	10	9	—	10	7	—	10	10	—	10	6	—	10	[illegible]
9	—	10	10	—	10	9	—	10	6	—	10	10	—	10	6	—	10	10	—	10	6	—	10	[illegible]
9	—	10	10	—	10	9	—	10	10	—	10	9				—	9	8	—	10	10	—	10	[illegible]
	10			10			8			9			7			8			9			9		

it
% fouled; 10 = 0% fouled

ing and top coat lost exposing primer

13/ A few pin holes only
14/ Delamination of primer and top coat exposing zinc silicate coating

15/ Impossible to determine chc
because of extremely high
16/ Loss of top coat exposing g

B

T HUENEME AND SAN DIEGO (Contd)

	10			11						12						13					
	SD			PH			SD			PH			SD			PH			SD		
S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S
7	9	9	9	9	5	9	10	8	7	10	10	10	10	10	10	9	9	10	10	9	9
—	—	—	—	10	—	—	—	—	—	10	—	—	—	—	—	10	—	—	—	—	—
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
2	10	2	2	10	2	2	10	10	10	10	2	10	10	10	10	10	10	10	10	10	10
F	N	M	F	N	M	F	N	N	N	N	M	N	N	N	N	N	N	N	N	N	N
10	10	10	10	10	7	9	10	6	7	10	4 14/	10	10	2 14/	3 14/	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	9	9	10	6	9	10	8	7	10	10	10	10	10	10	10	10	10	10	10	10
10	9	9	9	9	6	10	10	8	7	10	10	10	10	10	10	9	9	10	10	9	9
8	9	9	9	10	6	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
8	10	10	10	10	9	10	10	9	9	10	10	10	10	10	10	10	10	10	10	10	10
H	—	M	M	—	M	H	—	M	H	—	M	M	—	L	M	—	H	H	—	M	M
1	—	1	1	—	1	1	—	0	1	—	2	1	—	5	3	—	1	1	—	2	1
8	—	9	8	—	9	9	—	9	9	—	9	9	—	9	8	—	9	9	—	9	8
1	—	1	3	—	1	1	—	0	1	—	2	1	—	5	3	—	1	1	—	2	2
10	—	9	6	—	10	10	—	9	7	—	10	10	—	9	8	—	10	10	—	9	7
7	—	1	6	—	2	9	—	0	7	—	3	8	—	5	3	—	6	8	—	2	8
5	—	10	9	—	7	3	—	10	9	—	7	6	—	10	9	—	3	7	—	10	9
6	—	10	10	—	10	6	—	10	10	—	10	7	—	10	10	—	10	7	—	10	10
8	—	10	9	—	10	7	—	10	10	—	10	6	—	10	10	—	10	7	—	10	10
6	—	10	10	—	10	6	—	10	10	—	10	6	—	10	10	—	10	6	—	10	9
0	—	10	9				—	9	8	—	10	10	—	10	8	—	10	10	—	9	8
	9			7			8			9			9			9			9		

A few pin holes only

Delamination of primer and top coat exposing zinc silicate coating

15/ Impossible to determine chalking on San Diego panels because of extremely high tide at time of inspection

16/ Loss of top coat exposing gray seal coat

C